

COMPREHENSIVE ENGINE MONITOR AND RECORDER

RELATED PATENT APPLICATIONS

This patent application is a continuation-in-part of my co-pending prior U.S. patent application Ser. No. 335,841, now U.S. Pat. No. 4,575,803, filed Dec. 30, 1981.

FIELD OF THE INVENTION

This invention relates to turbine engine monitoring, recording and data transfer systems, with particular emphasis on engine trend monitoring, and on exceedances, or operation of the engine beyond the manufacturer's temperature, torque or speed specifications.

BACKGROUND OF THE INVENTION

It is well known that aircraft turbine engines must be periodically overhauled; and that turbine engine overhaul is an expensive and time-consuming operation, normally costing well over \$50,000 for a major overhaul. Various proposals have been made heretofore to monitor use and abuse of aircraft turbine engines, and typical prior patents which have been directed to one aspect of this situation or another include J. Codomo U.S. Pat. No. 3,946,364, granted Mar. 23, 1976; M. S. Moore and C. F. Paluka U.S. Pat. No. 3,931,619; and M. S. Moore and C. F. Paluka U.S. Pat. No. 4,116,052, for example. Each of these patents is directed to a specific problem but does not provide all of the information which is desirable for measuring and analyzing the causes, current status, and the trend of aircraft turbine engine degradation.

Incidentally, with regard to engine trend monitoring and analysis, this is a well known procedure, and has in the past involved the manual recording of engine data on a periodic basis, perhaps once each flight when the aircraft has reached stable flight conditions. However, because the manual recording of the necessary data takes some finite period of time, readings of all of the instruments are not taken simultaneously, and errors in reading or recording may introduce undesired deviations in the results. This adverse effect is, of course, due in part to the changes in conditions which occur during the time period required for systematically recording all of the data manually.

Accordingly, an important object of the present invention is the provision of a comprehensive engine monitoring and recording system, which will automatically record basic data involving engine use, abuse and exceedances, and also automatically record all of the basic data for engine trend monitoring, so that errors due to manual trend monitoring data recording are estimated. In addition, it is a further object of the invention to tabulate and display the basic data on aircraft turbine engine use and abuse, or summaries thereof, so that the aircraft owner or user may exercise appropriate management control to minimize the need for costly overhaul and repairs.

Concerning another aspect of aircraft operation, the failure of certain aircraft instruments may require the grounding of the aircraft, until the instrument may be repaired or replaced.

Accordingly, a collateral object of the invention is to provide back-up instrumentation, so that in many cases an aircraft need not be grounded merely because one

aircraft instrument is not providing a correct output reading.

As noted above, this is a continuation-in-part of the prior pending U.S. patent application Ser. No. 335,841, filed Dec. 30, 1981. The systems as set forth in the present specification and drawings include all of the functions as disclosed in the prior patent application and a number of additional features to make a more comprehensive system. Accordingly, for completeness, the invention background section from Application Ser. No. 335,841 will be included in the following section of this application.

It has previously been proposed to monitor the temperature of a turbine engine, particularly at over-temperature levels, and one such over-temperature monitoring system is disclosed in U.S. Pat. No. 3,931,619. Another system of this general type is disclosed in the co-pending patent application of Geoffrey Hancock, U.S. Pat. application Ser. No. 197,008, filed Oct. 14, 1980, now U.S. Pat. No. 4,315,296, and assigned to the assignee of the present invention. In these prior arrangements, predetermined weighting characteristics were established and alarm signals were energized when the turbine engine exceeded such predetermined overall limits. These control systems characteristically involve a summation function in which the time at some very high temperature would be equated to a longer time at a slightly lower temperature, and the sum of the weighted factors would be employed to provide an output indication which would give a rough indication of the over-temperature stress or damage to the turbine engine which may have occurred.

However, it would be desirable to have a more accurate indication of the precise amount of time that the turbine engine has been operated, and that it has been operated at particular temperature levels. In addition, supplemental information such as the number of times that the engine has started is also relevant in determining whether periodic maintenance of the engine is appropriate. Further, in the analysis of the maintenance status of a turbine engine or the reason for certain anomalies in engine performance, it is frequently desirable to be able to determine the details of the recent past history of the operation of the engine in greater detail than has been possible heretofore.

Accordingly, the present invention is intended to overcome the shortcomings of the prior art systems and to provide the more complete historical information of the type outlined hereinabove.

SUMMARY OF THE INVENTION

In accordance with a specific illustrative embodiment of the invention, a turbine engine monitor and recorder includes a non-volatile storage for storing data relating to one or more of the critical engine operating parameters, such as:

1. Temperature
2. Torque
3. Engine Speed
4. Vibration
5. Fuel Flow

In addition, other information may be concurrently stored for analysis purposes, and this additional information may include (1) time and date, (2) outside air temperature (O.A.T.) (3) altitude and (4) air speed. Also of interest in analyzing engine performance, overhaul scheduling, and engine use and abuse, (1) the number of engine starts and (2) the number of power cycles, both